

## Multidisciplinary Design Optimization Using Genetic Algorithms

Resit Unal  
Associate Professor  
Old Dominion University  
Norfolk, VA 23529

Multidisciplinary design optimization (MDO) is an important step in the conceptual design and evaluation of launch vehicles since it can have a significant impact on performance and life cycle cost. The objective is to search the system design space to determine values of design variables that optimize the performance characteristic subject to system constraints. Gradient-based optimization routines have been used extensively for aerospace design optimization. However, one limitation of gradient based optimizers is their need for gradient information. Therefore design problems which include discrete variables can not be studied. Such problems are common in launch vehicle design. For example, the number of engines and material choices must be integer values or assume only a few discrete values.

In this study, genetic algorithms are investigated as an approach to MDO problems involving discrete variables and discontinuous domains. Optimization by genetic algorithms (GA) uses a search procedure which is fundamentally different from those gradient based methods [1,3,4]. Genetic algorithms seek to find good solutions in an efficient and timely manner rather than finding the best solution. GA are designed to mimic evolutionary selection [1,3,4]. A population of candidate designs is evaluated at each iteration, and each individual's probability of reproduction (existence in the next generation) depends on its fitness value (related to the value of the objective function). Progress toward the optimum is achieved by crossover and mutation operations [2,3,4]. GA is attractive since it uses only objective function values in the search process, so gradient calculations are avoided. Hence, GA are able to deal with discrete variables. Studies report success in the use of GA for aircraft design optimization studies, trajectory analysis, space structure design and control systems design [1,2,4]. In these studies reliable convergence was achieved, but the number of function evaluations was large compared with efficient gradient methods.

Application of GA is underway for a cost optimization study for a launch-vehicle fuel-tank and structural design of a wing. The strengths and limitations of GA for launch vehicle design optimization is studied.

### References

1. P.Gage and I Kroo, 1993, "A Role for Genetic Algorithms in a Preliminary Design Environment," AIAA-93-3933, August.
2. P.Gage, R.D. Braun and I Kroo, 1994, "Interplanetary Trajectory Optimization Using a Genetic Algorithm," AIAA-94-3773, August.
3. D.E. Goldberg, 1989, Genetic Algorithms in Search, Optimization, and Machine Learning, Addison Wesley, Reading, Massachusetts.
4. M. Srinivas and L.M. Patriak, 1994, "Genetic Algorithms: A Survey," Computer, (IEEE) Vol. 27, No. 6, June.